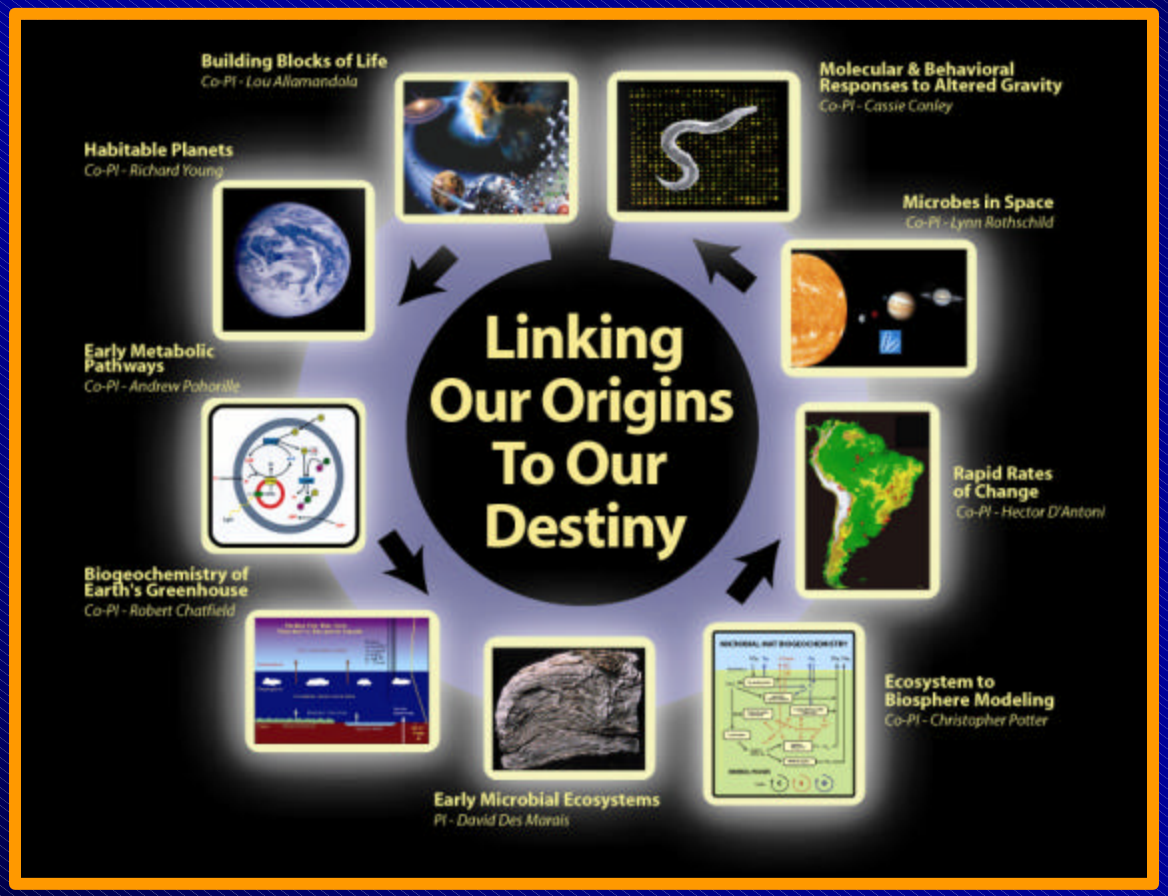
NASA ASTROBIOLOGY RESEARCH TEAM

Charting the origins, evolution and distribution of life in the Universe requires astronomers, biochemists, biologists, and Earth and planetary scientists. The Ames team includes all of these disciplines, therefore its research strengthens our understanding of the linkages between our origins, evolution and destiny.



Education and Public Outreach

Catherine J. Tsairides - Project Director

AMES ASTROBIOLOGY INSTITUTE TEAM

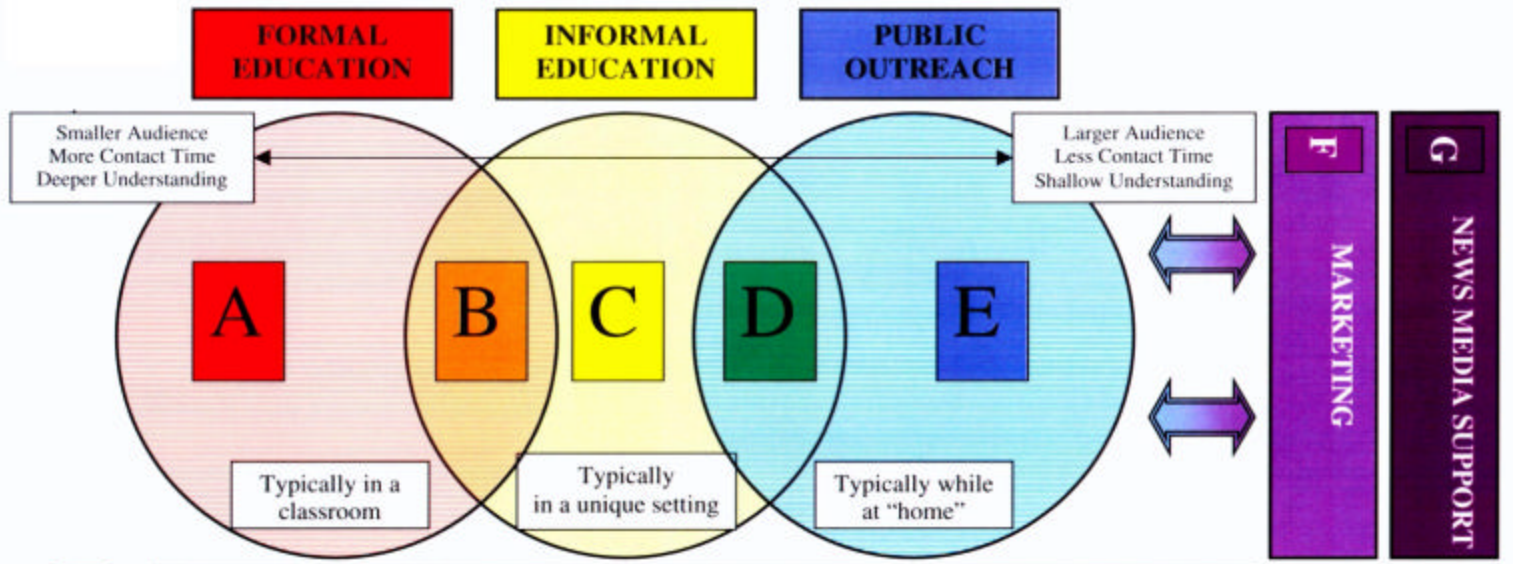
"Linking Our Origins to Our Destiny"

- **Chemical Building Blocks of Life**
  - L. Allamandola*, M. Bernstein, J. Dworkin, D. Deamer, R. Zare, S. Sandford
- **Habitable Planets and Atmospheres**
  - R. Young*, J. Chambers, J. Cuzzi, J. Lissauer, D. Hollenbach, N. Rosenberg, M. Zolensky, J. Kasting, N. Sleep, K. Zahnle, R. Haberle, S. Thompson, B. Toon
  - R. Chatfield*, K. Zahnle
- **Evolution of Early Metabolic Pathways/Replication**
  - A. Pohorille*, J. Lanyi, J. Szostak, D. Wolpert, A. Keefe, M. New, M. Wilson, D. Deamer, F. Szoka, A. Drukier
- **Early Microbial Ecosystems – Modern Analogs**
  - D. Des Marais*, R. Castenholz, D. Ward, B. Bebout, F. Garcia-Pichel, L. Prufert-Bebout, P. Visscher, D. Canfield, K. Londry, K. Cullings, L. Jahnke, R. Summons, P. Reid, S. Cady, J. Farmer
  - C. Potter*
- **Future of Life – Ecosystem Change, Radiation, etc.**
  - H. D'Antoni*, E. Metzger, P. Messina
  - L. Rothschild*, R. Mancinelli, G. Horneck, P. Rettberg, D. Wynn-Williams, et al.
  - C. Conley*

NASA OFFICE OF SPACE SCIENCE EDUCATION AND PUBLIC OUTREACH GOALS

- Use our missions and research programs and the talents of the space science community to contribute measurably to efforts to reform science, mathematics, and technology education, particularly at the pre-college level, and the general elevation of scientific and technical understanding throughout the country.
- Cultivate and facilitate the development of strong and lasting partnership between the space science community and the communities responsible for science, mathematics, and technology education.
- Contribute to the creation of the talented scientific and technical workforce needed for the 21st century.
- Promote the involvement of the underserved/underutilized groups in Space Science education and outreach program and their participation in Space Science Research and development activities.
- Share in the excitement of discoveries and knowledge generated by Space Science missions and research programs by communicating clearly with the public.

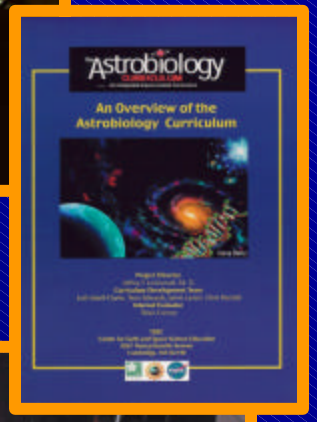
OUTREACH ACTIVITIES



A	Curriculum; Textbooks; Teacher workshops; Ugrad intro courses; Systemic reform; Home schooling…	EPO
B	Ed. programs at museums/libraries/parks; Elderhostel classes; Scout badges; Science fairs; Internships…	
C	Museum exhibits/kiosks; Field trips; Eclipse tours; Star parties; Career workshops; Parks displays…	
D	IMAX/Planetarium shows; Public talks; Slide shows/sets; Museum demos; Webcasts; Performing arts …	
E	Educational TV/Radio programs; Magazine/Encyclopedia articles; Popular books; Webchats…	
F	Display booths; Posters/brochures; Pins/stickers/patches; Hats/T-shirts; Bookmarks/postcards; Mugs…	Marketing
G	Press releases; Press conferences; Press kits for reporters; Video clips for TV news; Media interviews…	News Media Support

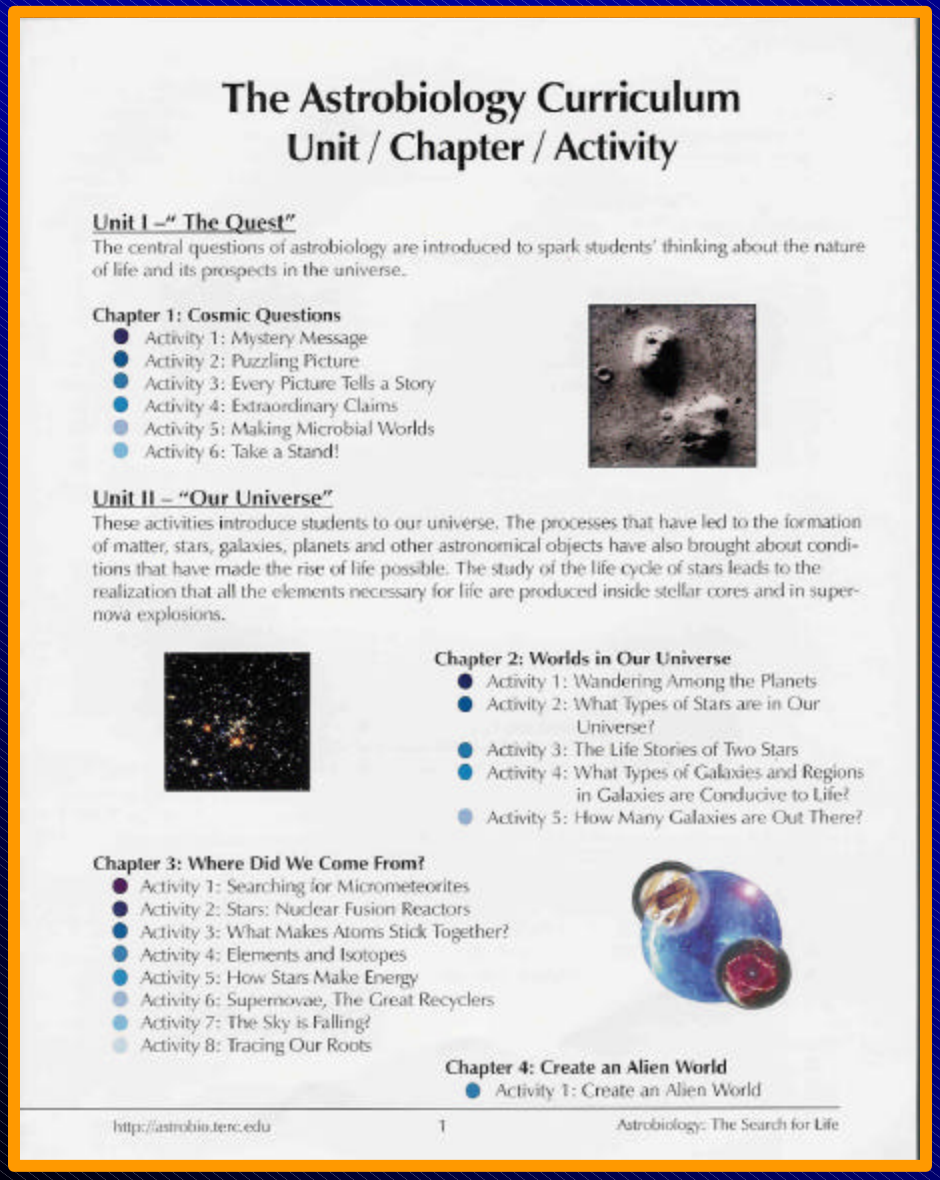
STUDENTS AND EDUCATORS

- **Coordinate development, distribution, and evaluation of materials in partnership with internal and external organizations.**



- Astrobiology Educator Resource Guide (TERC)
- The Astrobiology High School Curriculum (TERC), (It's About Time)
- Voyages Through Time CD High School Program (SETI Institute)
- EXOQUEST CD ROM program and Experts In Science Career Video (NASA's Classroom of the Future)
- AstroVenture Multimedia (NASA Education)
- Quest web-casts (NASA)
- National/International Science Conferences

ASTROBIOLOGY CHAPTER OUTLINE



The Astrobiology Curriculum
Unit / Chapter / Activity

Unit I –" The Quest"
The central questions of astrobiology are introduced to spark students' thinking about the nature of life and its prospects in the universe.

Chapter 1: Cosmic Questions
- Activity 1: Mystery Message
- Activity 2: Puzzling Picture
- Activity 3: Every Picture Tells a Story
- Activity 4: Extraordinary Claims
- Activity 5: Making Microbial Worlds
- Activity 6: Take a Stand!

Unit II – "Our Universe"
These activities introduce students to our universe. The processes that have led to the formation of matter, stars, galaxies, planets and other astronomical objects have also brought about conditions that have made the rise of life possible. The study of the life cycle of stars leads to the realization that all the elements necessary for life are produced inside stellar cores and in supernova explosions.

Chapter 2: Worlds in Our Universe
- Activity 1: Wandering Among the Planets
- Activity 2: What Types of Stars are in Our Universe?
- Activity 3: The Life Stories of Two Stars
- Activity 4: What Types of Galaxies and Regions in Galaxies are Conducive to Life?
- Activity 5: How Many Galaxies are Out There?

Chapter 3: Where Did We Come From?
- Activity 1: Searching for Micrometeorites
- Activity 2: Stars: Nuclear Fusion Reactors
- Activity 3: What Makes Atoms Stick Together?
- Activity 4: Elements and Isotopes
- Activity 5: How Stars Make Energy
- Activity 6: Supernovae, The Great Recyclers
- Activity 7: The Sky is Falling?
- Activity 8: Tracing Our Roots

Chapter 4: Create an Alien World
- Activity 1: Create an Alien World

http://astrobio.terc.edu 1 Astrobiology: The Search for Life

- Chapter 1 – Cosmic Questions
- Chapter 2 – Worlds in Our Universe
- Chapter 3 – Where Did We Come From?
- Chapter 4 – Create an Alien World
- Chapter 5 – What is Life?
- Chapter 6 – The Chemistry of Life
- Chapter 7 – Evolution and Diversity
- Chapter 8 – Cellular Basis of Life
- Chapter 9 – History of Life on Earth
- Chapter 10 – Revisiting Life
- Chapter 11 – What is Habitability?
- Chapter 12 – Finding Energy and Raw Materials on Habitable Worlds
- Chapter 13 – Planetary Systems that Contribute to a Planet's Habitability
- Chapter 14 – Are There Habitable Worlds in Our Solar System?
- Chapter 15 – Signals from Space
- Chapter 16 – How Do We Search?
- Chapter 17 – Searching for Extrasolar Planets
- Chapter 18 – Exploring Planets and Moons
- Chapter 19 – What if We Find Life?
- Chapter 20 – The End is the Beginning

ASTRO-VENTURE

What is Astro-Venture?

- Astro-Venture is an educational, interactive, multimedia Web environment highlighting NASA careers and astrobiology research in the areas of Astronomy, Geology, Biology and Atmospheric Sciences.
- Students in grades 5-8 are transported to the future where they role play NASA occupations and use scientific inquiry, as they search for and build a planet with the necessary characteristics for human habitation.
- Supporting activities include:
  - Chats with real NASA scientists
  - Online collaborations
  - Classroom lessons
  - Student publishing area
  - Occupation fact sheets and trading cards

National Aeronautics and Space Administration

Astrobiology

David Des Marais
Senior Research Space Scientist
Bio-Geo-Chemist
Astrobiologist
NASA Ames Research Center

The science of Astrobiology allows us to make predictions about **life forms** that future space missions might encounter on other planets. In my work, I study the **evolution** of micro-organisms over long periods of time, and then compare the findings with the corresponding changes in the Earth's evolution as a planet. To gather samples, our team goes to places with **extreme environments**, such as thermal springs, and parts of the sea where the salt content is high. In these extreme environments micro-organisms dominate, and scientists can study how they interact with each other. To learn about micro-organisms that lived billions of years ago, we also gather and study fossil samples.

Areas of expertise:

- **Geochemistry** of **carbon** in lunar samples, meteorites, and oceanic basalts and in ancient (precambrian) carbonates and organic matter
- Biogeochemistry of **microbial** communities in hypersaline and hydrothermal environments
- Search for **fossil** evidence of life in **Mars**

How I first became interested in this profession:

Growing up, I enjoyed exploring caves. As graduate student in the 1970s, I studied earth science (geology), and I remember being fascinated by the lunar samples we were able to study—which were brought to Earth by earlier NASA lunar missions. This experience led to my interest in space science. Later on I became involved with biology, which added a new dimension to my research. This led to my later work on how the carbon cycle relates to Earth's history and to astrobiology.

What helped prepare me for this job:

In high school and college, I studied chemistry, physics, mathematics and geology. Also, I learned that many questions that we have about our biosphere and environment required the application of more than one of these disciplines. I learned about the scientific method, which provides a logical approach to finding answers to mysteries that intrigue me.

My role models or inspirations:

I had a great high school chemistry teacher whose enthusiasm for chemistry and all science was infectious. A college professor introduced me to the wonders of geology. My graduate school thesis advisor revealed how the power of modern analytical chemistry can unveil the early history of our biosphere.

My education and training:

- Ph.D. in Geochemistry, Indiana University

My career path:

- One year as a Research Fellow at the Institute of Geophysics, University of California, Los Angeles (UCLA).
- Twenty-five years as research scientist in Exobiology, NASA Ames Research Center

What I like about my job:

I find space exploration motivating and extremely exciting because it fulfills a **natural desire**—intrinsic to human nature—to go out and search for **other** forms of **life**. I believe that our type of work drives the **pursuit** of **excellence** in science and technology, and I enjoy contributing to the process.

What I don't like about my job:

Most of the time, I cannot be in the lab. I spend a lot of time making sure that others in my lab can have the resources and other support that they need to do the research. But my supporting role is still a vital part of the team research effort.

My advice to anyone interested in this occupation:

As an undergraduate, be sure that you get a good foundation in chemistry, physics or mathematics, because they are the foundation of our efforts to learn the mysteries of life in the universe. As an undergraduate, try to get some experience in a research laboratory.

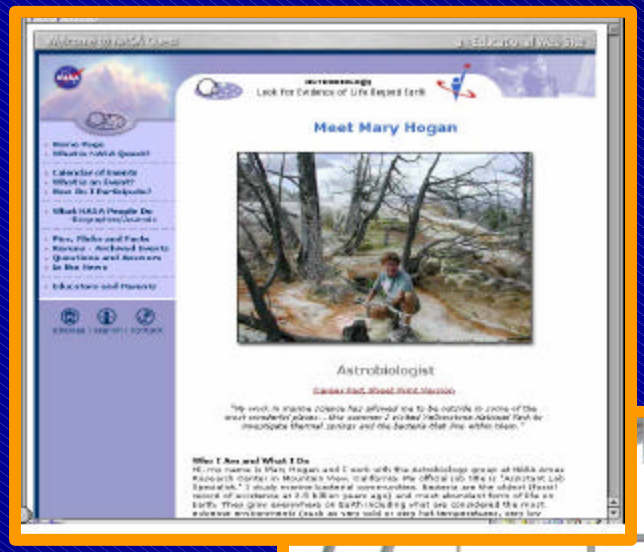
August 2001

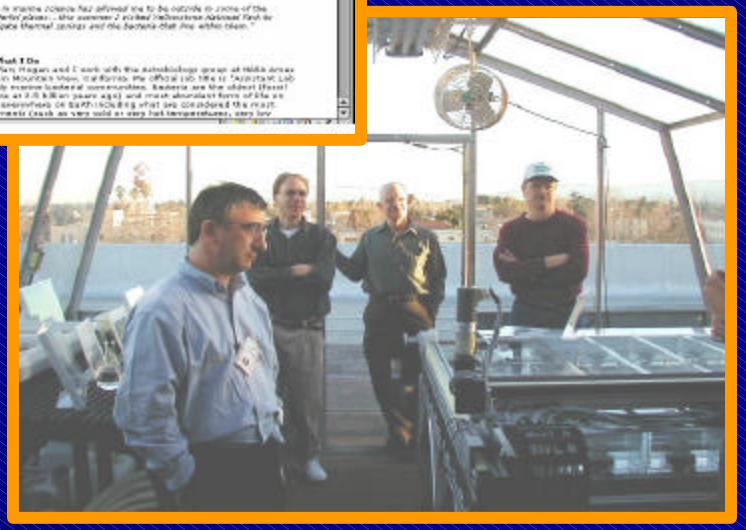
http://quest.nasa.gov/people/index.html

GENERAL PUBLIC

- **Involved in science and education meetings, tours, media, and conferences to provide research information, professional development, test, and distribute education products.**

  - Regional, National, and International conferences
  - External and Internal Organizational tours of the Astrobiology labs/greenhouses
  - Public lectures, seminars, and speaking engagements nationally and internationally
  - Expedition web-casts
  - Internet Access (http://nai.arc.nasa.gov)
  - Media (newspapers, television, Video)
  - Publications





INFORMAL EDUCATION

- **Developing high leverage education and outreach opportunities in support of long term partnerships**

- Yellowstone National Park
- Marine Science Institute
- Space Center Houston
- The Space Place (JPL)
- Traveling Exhibit (NAI)
- California Academy of Science
- Young Astronauts
- Public Science Symposiums
- Palo Alto Rotary Club

PUBLIC PRESENTATIONS

- **The Ames Astrobiology Research Team participates in public outreach by providing astrobiology lectures, presentations, exhibit material, and demonstrations to the public**
  - **Informal Education Presentations**
    - Yellowstone National Park, Wyoming
    - California Academy of Sciences, San Francisco, California
    - Eugene Natural History Society, Eugene, Oregon
    - Grand Teton National Park, Jackson Hole, Wyoming
    - Burpee Museum of Natural History, Rockford, Illinois
    - Marine Science Institute, Redwood City, California
  - **Professional Presentations**
    - American Academy of Microbiology, Tucson, Arizona
    - Lunar and Planetary Institute, Houston, Texas
    - Mars Exploration Payload Advisory Group, Jet Propulsion Laboratory, Pasadena, California
    - American Society for Limnology and Oceanography, Rutherford Appleton Laboratory, UK
  - **Public Presentations**
    - French Delegation, Ames Research Center, Moffett Field, California
    - University of Washington
    - Community Facility, Rio Gallegos Santa Cruz, Argentina
    - Stanford University, Palo Alto, California

YELLOWSTONE NATIONAL PARK

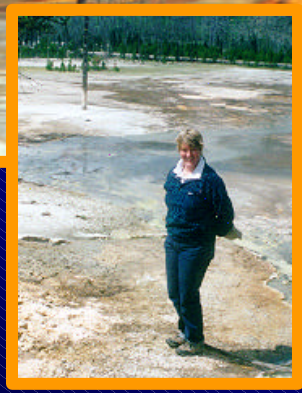
- Yellowstone National Park is considered a living laboratory where it's diverse resources, natural processes, and cultural history provide important and unique opportunities for research and education. The Ames Astrobiology team, it's NAI partners and the NASA Astrobiology Institute have initiated a focused outreach project with Yellowstone that highlights astrobiology and the research of the NAI members in the park, integrating the two.

Grand Prismatic at Yellowstone National Park

Dr. Baruch Blumberg
NASA Astrobiology Institute
Dr. Dave Ward
Montana State University
at Octopus Springs

Lynn Rothschild
NASA Ames Research Center
at Nymph Creek

Dr. Jack Farmer
Arizona State University
at Octopus Springs



Nancy Hinman
University of Montana
at Black Sand Pool

FOCUS ON CURRENT AND EMERGING RESEARCH

- **New and emerging research is critical to the understanding and problem solving of environmental issues.**
  - NASA is conducting research in Yellowstone in order to understand how life began on earth.
  - The pristine thermal springs of Yellowstone National Park provide access to a wide variety of environmental extremes resembling those that were widespread on early earth when life originated, and that are also found today on other bodies in our solar system, and possibly early Mars.
- **Current research on Yellowstone's thermal features will be incorporated in:**
  - Old Faithful Visitor Education Center
  - Trail Side Sign Project
  - Resources and Issues Guide
  - Trail Side Brochures
  - Junior Ranger Program

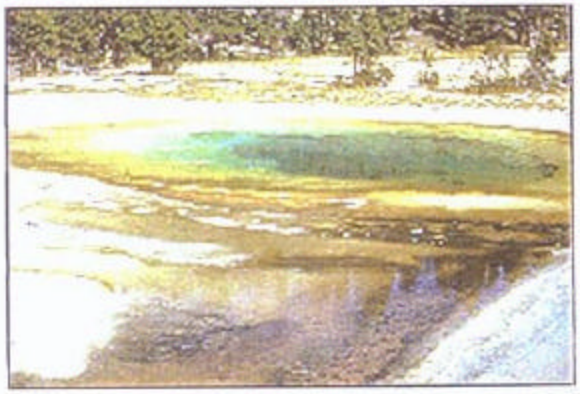
YELLOWSTONE NATIONAL PARK
Trailside Sign

Beauty and Chromatic Pools

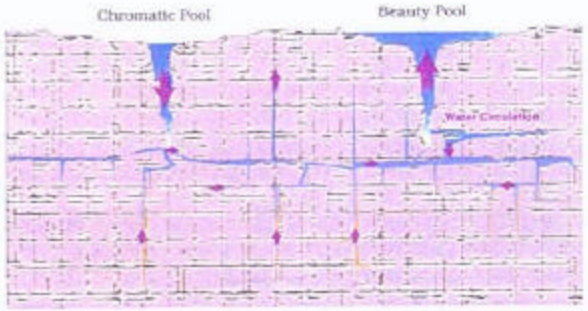
Living Color

The vivid colors of Beauty Pool's basin and runoff channels are created by microscopic lifeforms. Incredibly, these organisms survive and thrive in an environment that would be lethal to us and most other living creatures. Scientists are just beginning to understand these lifeforms; amazingly, hot spring environments may sustain a diversity of organisms rivaling that of terrestrial rain forests.

Chromatic Pool



Beauty Pool

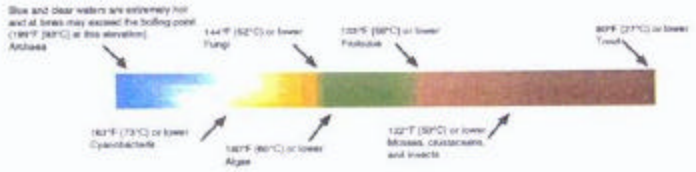


Hidden Connections

Beauty Pool shares an underground link with Chromatic Pool (to your immediate left). When Beauty Pool is full, Chromatic Pool's water level is much lower; sometimes the reverse may be observed. Many other features in the Upper Geyser Basin have demonstrated similar behavior. The factors affecting such *exchanges of function* are many and may include phenomena such as earthquakes and continuing mineral accumulations in each feature's underground "plumbing."

Thermal Feature Color Gradient

In the geyser basins with alkaline or neutral pH (Upper, Midway, Lower, West Thumb, and Mammoth Hot Springs), color is primarily a function of what lives and grows in a feature. The graph to the right represents the upper environmental temperature limits for life and the corresponding colors (which vary over the course of a year as a consequence of seasonal changes) in the features or runoff channels.



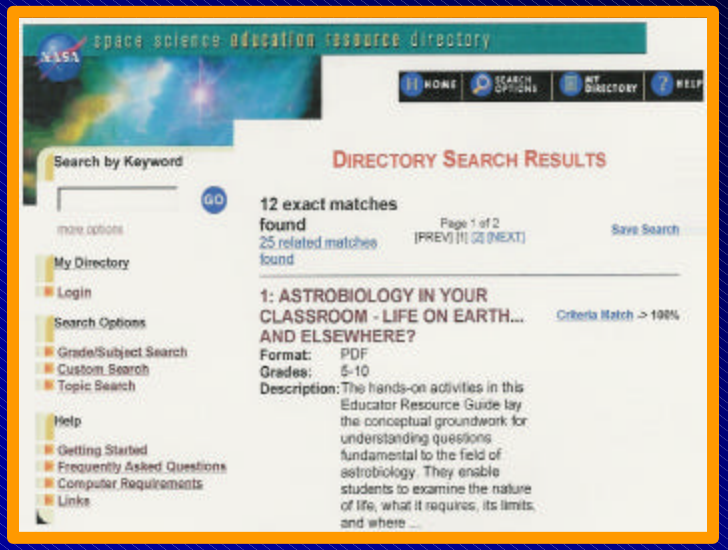
This exhibit made possible by a generous grant from the Yellowstone Association.

YELLOWSTONE NATIONAL PARK
Old Faithful Visitor Center

- **The art of interpretation is to provide the meaning behind the message -- to connect tangible and intangible resources**
  - Visitor understanding of these connections results in an appreciation of why the park exists and the significance of it's resources.
- **Integrated Approach**
  - Exhibits, literature, and curriculum materials will compliment and build upon partner expertise and facilities with a focus on the NASA Astrobiology Institute, Montana State University's Thermal Biology Institute, the United States Geological Survey, and many more.
- **Formal and Informal Education Components**
  - Curriculum based school programs - Classroom materials will be incorporated into the exhibit presentations. Curriculum will include astrobiology products that utilize the concept of science as a tool for exploration.

INTERNAL COLLABORATIONS

- **Coordinate with NASA Education and Outreach Efforts**
  - Participate in Origins Education Forum
  - Utilized Origins Forum Evaluation Team
  - NASA Astrobiology Institute Management/Lead teams
  - Project Performance Database
  - NAI Annual Report
  - NAI/Origins Management Meetings
  - Review panel Member (Cooperative Agreement Notice, IDEAS, Space Telescope Science Institute, Hubble Space Telescope)
  - Voyages In Educational and Public Outreach Space Science Newsletter
  - Videocon Lecture Series
  - Education Resource Directory
  - Education and Outreach Broker/Facilitator Program



POSTGRADUATE, GRADUATE, AND UNDERGRADUATE EDUCATION

- **Providing research opportunities**
  - National Research Fellows
  - Postdoctoral Research Staff
  - Graduate Students
  - Astrobiology Academy
  - Interns

UNDERGRADUATE / GRADUATE COURSE WORK

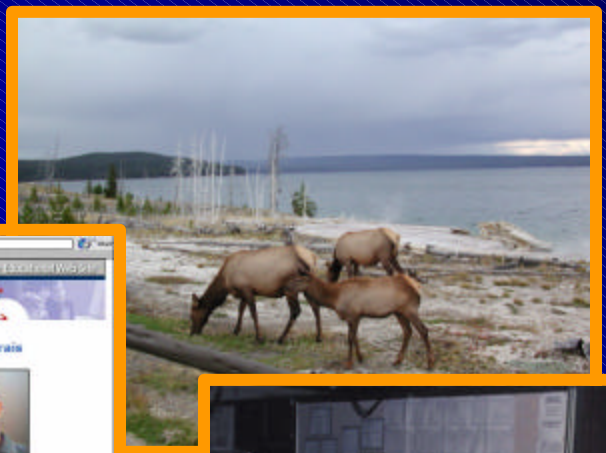
- **Increase the contribution of the astrobiology community to broaden public understanding of science at the college level**
  - Stanford University, Palo Alto , California
    - Astrobiology and Space Exploration
  - Hampton University, Norfolk, Virginia
    - Historically Black Colleges and Universities

NASA AMES ASTROBIOLOGY TEAM EDUCATION AND PUBLIC OUTREACH

✍ Connects Astrobiology Research and Activities with the American Public

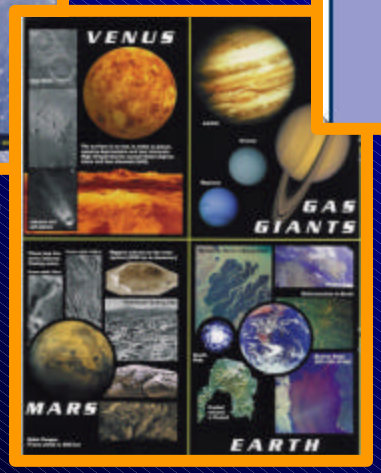
Respect and influence in the community

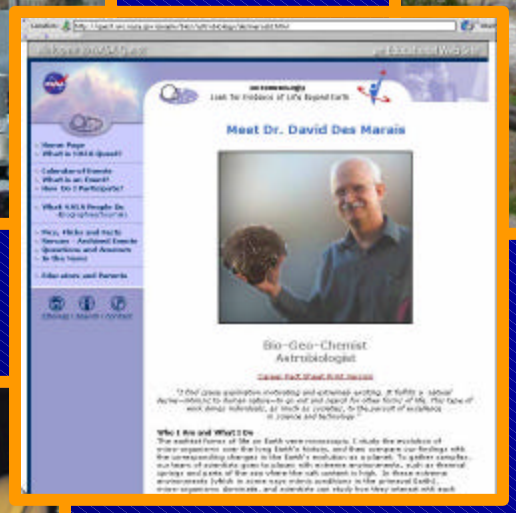
Access to data and facilities



Exciting connections to the real world

Resource for students, educators, informal education institutions, and curriculum developers





Role models for students

Science content knowledge and a deep understanding of the process of doing science